STUDENT BOOK ANSWERS

Chapter 7 Reactions in aqueous solutions

Experiment 7.1: Investigating precipitation reactions

Results (colour not shown)

ANION/ CATION	NO_3^- nitrate	Cl^- chloride	SO_4^{2-} sulfate	CO_3^{2-} carbonate	CH_3COO^- ethanoate	OH^- hydroxide
Na^+	*NR*	*NR*	*NR*	*NR*	*NR*	*NR*
Ag^+	*NR*	*P*	*P*	*P*	*NR*	*P*
Pb^{2+}	*NR*	*P*	*P*	*P*	*NR*	*P*
NH^{4+}	*NR*	*NR*	*NR*	*NR*	*NR*	*NR*
Mg^{2+}	*NR*	*NR*	*NR*	*P*	*NR*	*P*
Fe^{2+}	*NR*	*NR*	*NR*	*P*	*NR*	*P*
Cu^{2+}	*NR*	*NR*	*NR*	*P*	*NR*	*P*
Zn^{2+}	*NR*	*NR*	*NR*	*P*	*NR*	*P*
Al^{3+}	*NR*	*NR*	*NR*	*P*	*NR*	*P*
Ba^{2+}	*NR*	*NR*	*P*	*P*	*NR*	*NR*
Ca^{2+}	*NR*	*NR*	*P /NR*	*P*	*NR*	*NR/P*
Fe^{3+}	*NR*	*NR*	*NR*	*P*	*NR*	*P*

Discussion

1 **a** Students' answers may vary.

b There may be discrepancies as some compounds are slightly soluble or slightly insoluble. The temperature of the sample and amount used can cause the variation.

2 $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

$Pb^{2+}(aq) + 2Cl^-(aq) \rightarrow PbCl_2(s)$

$Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$

$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

$Ca^{2+}(aq) + SO_4^{2-}(aq) \rightarrow CaSO_4(s)$

$2Ag^+(aq) + CO_3^{2-}(aq) \rightarrow Ag_2CO_3(s)$

$Pb^{2+}(aq) + CO_3^{2-}(aq) \rightarrow PbCO_3(s)$

$Mg^{2+}(aq) + CO_3^{2-}(aq) \rightarrow MgCO_3(s)$

$Fe^{2+}(aq) + CO_3^{2-}(aq) \rightarrow FeCO_3(s)$

$Cu^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CuCO_3(s)$

$Zn^{2+}(aq) + CO_3^{2-}(aq) \rightarrow ZnCO_3(s)$

$Ba^{2+}(aq) + CO_3^{2-}(aq) \rightarrow BaCO_3(s)$

$Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$

$2Al^{3+}(aq) + 3CO_3^{2-}(aq) \rightarrow Al_2(CO_3)_3(s)$

$2Fe^{3+}(aq) + 3CO_3^{2-}(aq) \rightarrow Fe_2(CO_3)_3(s)$

$Ag^{+}(aq) + OH^{-}(aq) \rightarrow AgOH(s)$

$Pb^{2+}(aq) + 2OH^{-}(aq) \rightarrow Pb(OH)_2(s)$

$Mg^{2+}(aq) + 2OH^{-}(aq) \rightarrow Mg(OH)_2(s)$

$Fe^{2+}(aq) + 2OH^{-}(aq) \rightarrow Fe(OH)_2(s)$

$Cu^{2+}(aq) + 2OH^{-}(aq) \rightarrow Cu(OH)_2(s)$

$Zn^{2+}(aq) + 2OH^{-}(aq) \rightarrow Zn(OH)_2(s)$

$Al^{3+}(aq) + 3OH^{-}(aq) \rightarrow Al(OH)_3(s)$

$Fe^{3+}(aq) + 3OH^{-}(aq) \rightarrow Fe(OH)_3(s)$

Conclusion

Students' answers may vary.

Worked example 7.1

a $K_2S(aq) + Co(CH_3COO)_2(aq) \rightarrow 2CH_3COOK(aq) + CoS(s)$

$S^{2-}(aq) + Co^{2+}(aq) \rightarrow CoS(s)$

b **i** $Cu(OH)_2$ copper hydroxide

ii None produced

iii $PbSO_4$ lead sulfate

c The target ion is the calcium ion. A solution containing sulfite, carbonate, sulphate or phosphate ions should precipitate the calcium ion.

Question set 7.1

1 A solid produced from the reaction of two solutions

2 Ions that are present in a solution but not involved in the reaction

3 **a** Soluble

b Insoluble

c Soluble

d Insoluble

e Soluble

4 **a** Potassium nitrate and zinc chloride

b Ammonium carbonate and sodium sulfate

c Magnesium sulfate and copper bromide

5 a $NaCl(aq) + AgNO_3(aq) \rightarrow NaNO_3(aq) + AgCl(s)$

b $CuSO_4(aq) + 2KOH(aq) \rightarrow Cu(OH)_2(s) + K_2SO_4(aq)$

c $NiCl_2(aq) + K_2SO_4(aq) \rightarrow 2KCl(aq) + NiSO_4(s)$

d $Na_2CO_3(aq) + FeSO_4(aq) \rightarrow FeCO_3(s) + Na_2SO_4(aq)$

e $Zn(NO_3)_2(aq) + (NH_4)_2S(aq) \rightarrow 2NH_4NO_3(aq) + ZnS(s)$

f $K_2CO_3(aq) + CaCl_2(aq) \rightarrow 2KCl(aq) + CaCO_3(s)$

6 a $Na_2CO_3(aq) + MgCl_2(aq) \rightarrow 2NaCl(aq) + MgCO_3(s)$

b $Pb(NO_3)_2(aq) + CuSO_4(aq) \rightarrow PbSO_4(s) + Cu(NO_3)_2(aq)$

c $NaBr(aq) + AgNO_3(aq) \rightarrow NaNO_3(aq) + AgBr(s)$

7 B

8 a Need to test for lead or barium ions as nitrate ion is common to both. Add sodium hydroxide to the solution. Barium hydroxide is insoluble and lead hydroxide is not.

b Need to test for copper or iron ions as the sulfate ion is common to both. Copper sulfate is blue and iron sulfate is green.

Worked example 7.2

a i $c = \frac{n}{V} = \frac{0.2}{1.5} = 0.133\,\text{M}$

ii $c = \frac{n}{V} = \frac{0.04}{0.45} = 0.089\,\text{M}$

b i $n = \frac{m}{M} = \frac{8}{74.6} = 0.107\,\text{mol}$

$c = \frac{n}{V} = \frac{0.107}{0.25} = 0.43\,\text{M}$

ii $n = \frac{m}{M} = \frac{1.46}{151.8} = 0.0096\,\text{mol}$

$c = \frac{n}{V} = \frac{0.0096}{0.100} = 0.096\,\text{M}$

iii $n = \frac{m}{M} = \frac{7.5}{169.9} = 0.044\,\text{mol}$

$c = \frac{n}{V} = \frac{0.044}{0.500} = 0.088\,\text{M}$

c i $n = CV = 0.200 \times 2.00 = 0.400\,\text{mol}$

$M(\text{NaI}) = 149.9\,\text{g mol}^{-1}$

$m = nM = 0.400 \times 149.9 = 60.0\,\text{g}$

ii $n = CV = 0.01 \times 0.250 = 0.0025\,\text{mol}$

$M(K_3PO_4) = 213.3\,\text{g mol}^{-1}$

$m = nM = 0.0025 \times 213.3 = 0.533\,\text{g}$

iii $n = CV = 0.0075 \times 0.500 = 0.00375\,\text{mol}$

$M(\text{Ba (NO}_3)_2) = 261.3\,\text{g mol}^{-1}$

$m = nM = 0.00375 \times 261.3 = 0.980\,\text{g}$

Worked example 7.3

a $2NaOH(aq) + CuSO_4(aq) \rightarrow Na_2SO_4(aq) + Cu(OH)_2(s)$

$n(\text{NaOH}) = CV = 0.450 \times 0.100 = 0.0450\,\text{mol}$

$n(\text{Cu(OH)}_2) = \frac{1}{2}n(\text{NaOH}) = 0.0225\,\text{mol}$

$m = nM = 0.0225 \times 97.6 = 2.20\,\text{g}$

b $Na_2CO_3(aq) + MgCl_2(aq) \rightarrow 2NaCl(aq) + MgCO_3(s)$

$n(\text{MgCl}_2) = CV = 0.08 \times 0.075 = 0.0060\,\text{mol}$

$n(\text{MgCO}_3) = n(\text{MgCl}_2) = 0.0060\,\text{mol}$

$m = nM = 0.0060 \times 84.3 = 0.51\,\text{g}$

c $ZnCl_2(aq) + 2NaOH(aq) \rightarrow Zn(OH)_2(s) + 2NaCl(aq)$

$n(\text{ZnCl}_{2)} = CV = 0.500 \times 0.010 = 0.0050\,\text{mol}$

$n(\text{Zn(OH)}_2) = \text{n}(\text{ZnCl}_2) = 0.0050\,\text{mol}$

$m = nM = 0.0050 \times 99.4 = 0.50\,\text{g}$

Question set 7.2

1 Concentration is the amount of a solute present in a specified amount of solution. Molarity is the number of moles of a substance in one litre of a solution.

2 **a** **i** $c = \frac{n}{V} = \frac{1.5}{2.0} = 0.75\,\text{mol L}^{-1}$

ii $n = 1.5$ mol, $m = nM = 1.5 \times 119 = 178.5$

This was in 2 L so there is $89.25\,\text{g L}^{-1}$

b **i** $c = \frac{n}{V} = \frac{0.0025}{0.250} = 0.010\,\text{mol L}^{-1}$

ii $n = 0.0025\,\text{mol}$, $m = nM = 0.0025 \times 149.9 = 0.375$

This was in 0.25 L so there is $1.50\,\text{g L}^{-1}$

3 **a** $n = CV = 0.40 \times 0.100 = 0.040\,\text{mol}$

b $n = CV = 0.15 \times 0.500 = 0.075\,\text{mol}$

c $n = CV = 0.032 \times 2.00 = 0.064\,\text{mol}$

4 **a** $m = nM = 0.040 \times 261.3 = 10.5\,\text{g}$

b $m = nM = 0.075 \times 142 = 10.7\,\text{g}$

c $m = nM = 0.064 \times 134.5 = 8.6\,\text{g}$

5 **a** $n = \frac{m}{M} = \frac{199}{218.5} = 0.911\,\text{mol}$

$c = \frac{n}{V} = \frac{0.911}{5.00} = 0.182\,\text{M}$

b $n = \frac{m}{M} = \frac{0.059}{58.1} = 0.0010\,\text{mol}$

$c = \frac{n}{V} = \frac{0.001}{0.227} = 0.0044\,\text{M}$

c $n = \frac{m}{M} = \frac{23}{46} = 0.50\,\text{mol}$

$c = \frac{n}{V} = \frac{0.50}{0.750} = 0.67\,\text{M}$

6 **a** $n = CV = 0.02 \times 0.025 = 0.0005\,\text{mol}$

$M(\text{Na}_2\text{CO}_3) = 106\,\text{g mol}^{-1}$

$m = nM = 0.0005 \times 106 = 0.053\,\text{g}$

b $n = CV = 0.10 \times 0.032 = 0.0032\,\text{mol}$

$M(\text{CuSO}_4) = 159.7\,\text{g mol}^{-1}$

$m = nM = 0.0032 \times 159.7 = 0.51\,\text{g}$

7 $v = \frac{n}{C} = \frac{0.0010}{0.025} = 0.04\,\text{L}$

8 $\text{NaI(aq)} + \text{AgNO}_3\text{(aq)} \rightarrow \text{AgI(s)} + \text{NaNO}_3\text{(aq)}$

$n = CV = 0.15 \times 0.025 = 0.00375\,\text{mol}$

$m = nM = 0.00375 \times 234.8 = 0.88\,\text{g}$

9 **a** Precipitate was CaCO_3. $n = \frac{m}{M} = \frac{1.72}{100.1} = 0.0172\,\text{mol}$

$c = \frac{n}{V} = \frac{0.0172}{0.50} = 0.034\,\text{M}$

b $C = 0.034\,\text{M}$, $\text{n}(\text{Ca}^{2+}) = 0.034$ mol per litre

$m = nM = 0.034 \times 40.1 = 1.38\,\text{g}$ in one litre

c Yes

Worked example 7.4

a $c_1V_1 = c_2V_2$

$V_1 = \frac{0.10 \times 2.5}{18} = 13.9\,\text{mL}$

b **i** $c_1V_1 = c_2V_2$

$C_2 = \frac{5 \times 0.010}{0.200} = 0.25\,\text{M}$

ii $c_1V_1 = c_2V_2$

$V_1 = \frac{0.10 \times 0.10}{0.25} = 40\,\text{mL}$

c $c_1V_1 = c_2V_2$

$$C_1 = \frac{0.48 \times 0.065}{0.010} = 3.12\,\text{M}$$

Experiment 7.2: Preparing and diluting solutions

Analysing the results

2 **a** The colour intensity decreases with the dilutions.

b The concentration decreases. The student should use their calculated values to answer this question. Each dilution should be 10%.

c The mass of decreases. The student should use their calculated values to answer this question. Each dilution should be 10%.

Discussion

1 **a** Depends on the sample the teacher prepares.

b Depends on the sample the teacher prepares. If the unknown concentration is very close to one of the standards it should be easier. If the unknown was between the two standards and a lower concentration judging the colour would be hard.

c A colorimeter or light meter could be used.

2 Take a 50 mL pipette of solution 1 and make up to 250 mL. Alternatively the 25 mL aliquot could have been made up to 125 mL. This will be more concentrated than solution 2 which was prepared by taking 25 mL of solution 1 and making up to 250 mL.

Question set 7.3

1 An acid is a substance that produces hydrogen ions in solution. A base is a substance that contains OH^- or O^{2-} ions in solution or by reaction with water.

2 The reaction of an acid and a base to give salt and water.

3 When a hydrogen ion attaches to a water molecule it is called a hydronium ion. The hydronium ion is the more correct term, as all hydrogen ions in aqueous solutions would be present as hydronium ions.

4 **a** $HNO_3(aq) \rightarrow H^+(aq) + NO_3^-(aq)$

b $HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$

c $H_3PO_4(aq) \rightarrow 3H^+(aq) + PO_4^{3-}(aq)$

5 **a** $Ca(OH)_2$: slightly soluble; CuO: soluble; NH_4OH: soluble; Na_2O: soluble

b $Ca(OH)_2$: $Ca(OH)_2(aq) \rightarrow Ca^{2+}(aq) + 2OH^-(aq)$

CuO: $CuO(aq) \rightarrow Cu^{2+}(aq) + O^{2-}(aq)$

NH_4OH: $NH_4OH(aq) \rightarrow NH^{4+}(aq) + OH^-(aq)$

Na_2O: $Na_2O \rightarrow 2Na^+(aq) + O^{2-}(aq)$

6 **a** $HNO_3(aq) + KOH(aq) \rightarrow KNO_3(aq) + H_2O(l)$

b $H_2SO_4(aq) + ZnO(aq) \rightarrow ZnSO_4(aq) + H_2O(l)$

c $2HF(aq) + Mg(OH)_2(s) \rightarrow MgF_2(aq) + 2H_2O(l)$

d $H_3PO_4(aq) + 3NH_3(aq) \rightarrow (NH_4)_3PO_4(aq)$

e $2CH_3COOH(aq) + Na_2O(aq) \rightarrow 2CH_3COONa(aq) + H_2O(l)$

f $CaO(aq) + 2NH_4NO_3(aq) \rightarrow Ca(NO_3)_2(aq) + 2NH_3(aq) + H_2O(l)$

7 a Weigh out the salt, Na_2SO_4. Carefully transfer the salt to a 250 mL volumetric flask. Add just enough water to dissolve the salt. Swirl the volumetric flask with lid, carefully, until the salt dissolves. Once dissolved, fill with water up to 250 mL mark.

b The water could be evaporated.

c The glassware should be clean and washed with distilled water. Distilled water should be used to fill the volumetric flask.

Experiment 7.3: Measuring pH

Analysis of results

1 This will depend on the samples chosen.

2 This will depend on the samples chosen.

3 This will depend on the samples chosen.

Discussion

1 Colour of the sample may mask the universal indicator colour change.

2 The method could be diluting the soil and measuring the pH of the water, or making a paste of soil and water.

3 This will depend on the samples chosen.

4 Answers may vary.

5 Answers may vary.

Conclusion

Answers may vary.

Worked example 7.5

a $H_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$

$n = CV = 2 \times 0.500 = 1.00$ mol of H_2SO_4

$n(KOH) = 2 \times n(H_2SO_4) = 2.00$ mol

$m = nM = 2.00 \times 56.1 = 112$ g of KOH

b $2HNO_3(aq) + Mg(OH)_2(s) \rightarrow Mg(NO_3)_2(aq) + 2H_2O(l)$

$n = CV = 0.25 \times 1.00 = 0.25$ mol of HNO_3

$n(Mg(OH)_2) = 0.5 \times n(HNO_3) = 0.125$ mol

$m = nM = 0.125 \times 58.3$ g $= 7.29$ g of $Mg(OH)_2$

c $c_1V_1 = c_2V_2$ $C^1 = 10^{-1} = 0.1\,\text{M}$

$C_2 = \dfrac{0.1 \times 1}{1000} = 0.0001\ \text{M} = 1 \times 10^{-4}\,\text{M}$

pH = 4

d Concentrated by a factor of 10, so pH increases by 1 to become 10.

Question set 7.4

1 **a** pH is a measure of the concentration of H^+ ions.

b It provides a measure of the acidity or alkalinity of aqueous solutions.

2 **a** Substances that change colours in solutions depending on whether the solution is acidic or basic

b To measure the acidity and alkalinity of solutions or when a change in these occurs

3 **a** T

b F. A soluble base is called an alkali.

c F. A substance that is neither acid nor base is neutral.

d T

e F. An acid turns litmus red while a base turns litmus blue.

4 pH measures the concentration of hydrogen ions in the solution. The lower the pH the more acidic the solution is. The higher the pH the more basic the solution is. As the H^+ ion increases in concentration the OH^- ion decreases in concentration.

5 An ant bite would need to be treated with a base, so ammonia would be better. A wasp sting would need to be treated with an acid, so vinegar would be better.

6 **a** pH 1–3

b pH 7

c pH 8–10

d pH 11–13

7 Diluted by a factor of 10 (100 mL $\rightarrow$ 1000 mL), so pH = 6

8 D

9 C would be correct between the pH range of 6–7

10 **a** It would be lower.

b $NaOH(aq) + CH_3OOH(aq) \rightarrow CH_3OONa(aq) + H_2O(l)$

$n(CH_3OOH) = CV = 0.83 \times 0.5\,\text{mol}$

$n(NaOH) = n(CH_3OOH) = 0.415\,\text{mol}$

$m = nM = 0.415 \times 40 = 16.6\,\text{g of NaOH}$

Question set 7.5

1 a Acid + base → salt + water

b Acid + metal → salt + hydrogen

c Acid + carbonate → salt + carbon dioxide + water

2 a $H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

b $2CH_3COOH(aq) + Ca(OH)_2(aq) \rightarrow (CH_3COO)_2Ca(aq) + 2H_2O(l)$

c $2HNO_3(aq) + Mg(s) \rightarrow Mg(NO_3)_2(aq) + H_2(g)$

d $2HCl(aq) + Zn \rightarrow ZnCl_2(aq) + H_2(g)$

e $2HF(aq) + Ca(HCO_3)_2(s) \rightarrow 2CaF_2(aq) + 2CO_2(g) + 2H_2O(l)$

f $2HNO_3(aq) + CuCO_3(s) \rightarrow Cu(NO_3)_2(aq) + CO_2(g) + H_2O(l)$

Experiment 7.4: Identifying unknown anions

Results

Test solution/anion	H^+	Ag^+	Pb^{2+}	Ba^{2+}	Ba^{2+} and OH^-
CO_3^{2-}	*Gas produced*	*Not tested*	*Not tested*	*Not tested*	*Not tested*
Cl^-	*NP*	*PPT white*	*PPT White*	*NP*	*NP*
SO_4^{2-}	*NP*	*PPT*	*PPT White*	*PPT white*	*PPT remains*
PO_4^{3-}	*NP*	*NP*	*NP*	*NP*	*PPT*

Analysis of results

Anion	Test and results
$OH^- Cl^-$	Gives a ppt with acidified Ag^+ but not with Ba^{2+}
SO_4^{2-}	Gives a ppt with acidified Ba^{2+}
PO_4^{3-}	Gives a ppt with Ba^{2+} in alkaline solution but not acid solution
CO_3^{2-}	Produces bubbles of gas with addition of dilute HNO_3

Discussion

1 Lead ions precipitate the chloride and sulfate ions. But so does the barium and silver ions. It can be used to identify the anions, but there are alternatives.

2 Carbonates are usually insoluble. So they are likely to precipitate along with the other anions. This means it is necessary to destroy the carbonate anion. This can be done by the addition of an acid. The acid reacts with the carbonate to form salt, carbon dioxide and water.

Conclusion

Students' results and answers may vary.

Chapter review questions

1 **a** A solid that is produced when two clear solutions are mixed

b A substance that produces hydrogen ions in solution

c A substance that contains OH^- or O^{2-} ions in solution or by reaction with water

d A measure of the acidity or alkalinity of a solution

e The amount of a solute present in a specified volume

2 An ion that is present in a solution but not involved in the reaction

3 When a hydrogen ion attaches to a water molecule it is called a hydronium ion. The hydronium ion is the more correct term, as all hydrogen ions in aqueous solutions would be present as hydronium ions.

4 pH measures the concentration of hydrogen ions in the solution. The lower the pH the more acidic the solution is. The higher the pH the more basic the solution is. As the H^+ ion increases in concentration the OH^- ion decreases in concentration.

5 **a** No

b $2NH_4Br(aq) + Pb(NO_3)_2\,(aq) \rightarrow 2NH_4NO_3(aq) + PbBr_2(s)$

$Pb^{2+}(aq) + 2Br^-(aq) \rightarrow PbBr_2(s)$

c No

d $SrCl_2(aq) + ZnSO_4(aq) \rightarrow SrSO_4(s) + ZnCl_2(aq)$

$Sr^{2+}(aq) + SO_4^{\ 2-}(aq) \rightarrow SrSO_4(s)$

6 There are many possible answers. Some are shown below.

a Lead sulfate: lead nitrate and sodium sulfate

b Iron(II) sulphide: iron chloride and sodium sulfide

c Magnesium hydroxide: sodium hydroxide and magnesium chloride

7 **a** $n = CV = 1.50 \times 2.00 = 3.00\,\text{mol}$

b $n = CV = 0.2 \times 3.5 = 0.7\,\text{mol}$

8 **a** $c = \frac{n}{V} = \frac{5.0}{2} = 2.5\text{ M}$

b $c = \frac{n}{V} = \frac{2.5}{0.50} = 5\text{ M}$

9 **a** $n = CV = 0.060 \times 0.5 = 0.030\,\text{mol}$

1 mol $Ba(OH)_2$ has 2 mol OH^-, so mol $Ba(OH)_2$ needed is 0.015 mol

$m = nM = 0.015 \times 171.3 = 2.57\,\text{g}$

b $n(H^+) = CV = 0.330 \times 0.25 = 0.0825\,\text{mol}$

1 mol H_2SO_4 has 2 mol H^+ so mol H_2SO_4 needed is 0.04125

$m = nM = 0.041 \times 98.1 = 4.05\,\text{g}$

10 **a** $c_1V_1 = c_2V_2$

$C_2 = \frac{0.242 \times 0.050}{0.500} = 0.0242\text{ M}$

b $c_1V_1 = c_2V_2$

$$C_2 = \frac{0.152 \times 0.025}{2.0} = 0.0019\,\text{M}$$

c $c_1V_1 = c_2V_2$

$$C_2 = \frac{0.114 \times 0.010}{0.250} = 0.00456\,\text{M}$$

11 a $c_1V_1 = c_2V_2$

$$V_1 = \frac{0.0113 \times 0.250}{0.282} = 0.0100\,\text{L}$$

b $c_1V_1 = c_2V_2$

$$V_1 = \frac{0.121 \times 2.0}{2.42} = 0.100\,\text{L}$$

c $c_1V_1 = c_2V_2$

$$V_1 = \frac{0.300 \times 1.0}{0.318} = 0.94\,\text{L}$$

12 a Purple

b Red

c No colour change

13 B

14 C

15 a $HNO_3(aq) + KOH(aq) \rightarrow KNO_3(aq) + H_2O(l)$

b $3HCl(aq) + Al(OH)_3(aq) \rightarrow AlCl_3(aq) + 3H_2O(l)$

c $H_2SO_4(aq) + Fe(s) \rightarrow FeSO_4(aq) + H_2(g)$

d $2CH_3COOH(aq) + MgCO_3(s) \rightarrow (CH_3COO)_2Mg(aq) + CO_2(g) + H_2O(l)$

e $H_3PO_4(aq) + 3NaHCO_3(s) \rightarrow Na_3PO_4(aq) + 3CO_2(g) + 3H_2O(l)$

16 If the solution contained lead nitrate then the addition of sodium chloride to the solution would cause the precipitate lead chloride to be formed. Calcium chloride is soluble so no precipitant would be formed.

17 Sodium carbonate. If sodium chloride was present then addition of silver nitrate would cause a precipitation of AgCl. If the carbonate was present then the addition of the acid would cause the bubbles. Nitric acid would react with carbonate to form salt, carbon dioxide and water. The bubble of gas could be due to the carbon dioxide gas being produced.

18 Barium ions. Barium ions form a precipitate with sulfate ions, barium gives a pale green flame colour whereas calcium gives a brick-red flame colour.

19 4 (Dilution of 100 mL to 1000 mL is 1:10.)

20 a $Ca(OH)_2 + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$

$n(HCl) = CV = 0.102 \times 0.00813 = 0.000829\,\text{mol}$

$n(Ca(OH)_2) = ½ \times n(HCl) = 0.000415\,\text{mol}$

$$C = \frac{n}{V} = \frac{0.000415}{0.025} = 0.0166\,\text{M}$$

b $C = 0.0166 \text{ mol L}^{-1}$

$m = nM = 0.0166 \times 74.1 = 1.23 \text{ g}$

Solubility is 1.23 g per litre

21 a $n = CV = 0.117 \times 0.0164 = 0.00192 \text{ mol}$

b $n(\text{Mg}) = n(\text{MgCl}_2) = 0.00192 \text{ mol}$

c $n(\text{Cl}^-) = 2n(\text{MgCl}_2) = 2 \times 0.00192 = 0.00383 \text{ mol}$

22 A: Pb^{2+}

B: Fe^{3+}. B is soluble with KI and H_2SO_4 but insoluble with NaOH so not Ba^{2+}. B did not precipitate with sulfuric acid: sulfates generally soluble the exceptions are Ba^{2+}, Pb^{2+} or Ca^{2+}. As these would precipitate so B cannot be one of these. Iron(III) hydroxide is a brown ppt. Copper hydroxide is blue and Iron (II) hydroxide is greenish but will change to brown over time as the Fe^{2+} becomes Fe^{3+}.

C: Ba^{2+}

D: Ca^{2+}

23 a $CaCl_2(aq) + H_2SO_4(aq) \rightarrow CaSO_4(aq) + 2HCl(aq)$

$n(\text{CaCl}_2) = \frac{m}{M} = \frac{22.22}{111.1} = 0.2000 \text{ mol}$

$n(\text{sulfuric acid}) = n(\text{CaCl}_2) = 0.2000 \text{ mol}$

$V(\text{H}_2\text{SO}_4) = \frac{n}{c} = \frac{0.2000}{0.500} \ 0.400 \text{ L}$

b $n(\text{CaSO}_4) = n(\text{CaCl}_2) = 0.2000 \text{ mol}$

$m = nM = 0.2000 \times 136.2 = 27.24 \text{ g}$

24 a Solution A

b Solutions could be i, iii

25 a E

b C

c Soil A has a pH of 4.0. The most acidic loving crop in the list is cotton at 5.0 − 6.0. Azalea would be the best to grow in the soil as they can cope with a pH of 4.5 − 5.5, yet they are not a crop.

d Soil B is slightly acidic with a pH of 5.0. Barley prefers a pH range of 6.0 − 8.0. It would need a base added to raise the pH.

e Soil B is slightly acidic with a pH of 5.0. They would have blue flowers.

26 a If lead is in the paint then the addition of a salt containing sulphate ions or iodine ions should produce a precipitate. Lead iodide has a characteristic yellow colour. The other components in the paint may interfere with this test. The levels could be too high to test in an AAS. However the paint could be diluted and then a sample run through the AAS to qualitatively determine the presence of lead.

b A set of lead standard solutions of a range of concentrations should be produced. Then these should be run in an AAS to determine the absorbance of each standard. A calibration curve should be produced of the absorbance against concentration. Then the acidic drink could be run through the AAS. The concentration of the lead in the drink could then be determined by using the calibration curve and the observed absorbance.